INDOOR AIR QUALITY ASSESSMENT

Falls Elementary School
One Jackson Street
North Attleborough, MA 02760

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Richard Smith, Superintendent, North Attleborough School Department, the Massachusetts Department of Public Health's (MDPH), Center for Environmental Health (CEH), was asked to provide assistance and consultation regarding indoor air quality in all of North Attleborough's public schools. On November 17, 2004, Cory Holmes and Sharon Lee, Environmental Analysts in CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program conducted an indoor air quality assessment at the Falls Elementary School located at One Jackson Street, North Attleborough, MA.

The FES is a two-story red brick building constructed in 1949. Two classrooms were reportedly added in the early 1980s and two modular classrooms, which serve as the library and computer room, were added in the early 1990s. It appears that the majority of building materials (e.g., floor tiles, heating and ventilation components, window systems) are original. The building has a history of roof leaks. Several months prior to the MDPH assessment, a new roof was installed over portions of the building, and other parts of the roof were patched/repaired. No active leaks were observed or reported. In addition to the new roof, school officials reported that the FES is on a waiting list to have the window systems replaced. At the time of the assessment the school was also awaiting electrical work to activate new rooftop exhaust vents in several areas.

Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity with the TSI, Q-TRAK™ IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). MDPH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

Results

The school houses approximately 280 students in kindergarten through fifth grades with approximately 25 staff members. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) parts of air in eighteen of twenty-four areas surveyed, indicating inadequate air exchange in the majority of areas throughout the school, mainly due to portions of the mechanical ventilation system being deactivated or inoperable. Fresh air in classrooms is supplied by a unit ventilator (univent) system (Picture 1). Univents are designed to draw air from outdoors through a fresh air intake located on the exterior walls of the building (Picture 2) and return air through an air intake located at the base of each unit (Figure 1). Fresh and return air are mixed and filtered, then heated and provided to classrooms through an air diffuser located in the top of the unit. Univents have manual fan controls of low, medium and high to adjust fan speed (Picture 3). Obstructions to airflow, such as papers and books stored on univents and bookcases, carts and desks in front of univent returns, were seen in a few classrooms. In order for univents to provide fresh air as designed, units must remain free of obstructions.

Exhaust ventilation in classrooms is provided by ducted, grated wall vents (Pictures 4 and 5) powered by rooftop motors. Exhaust vents in the 1949 portion of the building are equipped with a pull chain that adjusts a flue inside the vent (Picture 6). No exhaust vents were operating during the assessment, indicating that motors were deactivated or non-functional. As previously mentioned, a number of the exhaust motors had been replaced but were not wired at the time of the assessment. A number of exhaust vents were also obstructed by desks, bookcases and other items (Picture 7). As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions. In addition, the location of some exhaust vents can limit exhaust efficiency. In several rooms, exhaust vents are located near hallway doors. When these classroom doors are open exhaust vents become blocked (Picture 8). Exhaust vents in these rooms will also tend to draw air from both the hallway and the classroom reducing the effectiveness of the exhaust vent to remove common environmental pollutants.

The building was also designed to use openable windows to provide air exchange during summer months. Rooms are configured for cross-ventilation to provide comfort for building occupants. The building is equipped with windows on opposing exterior walls. In addition, the building has hinged windows located above the hallway doors. This hinged window, called a transom (Picture 9), enables classroom occupants to close the hallway door while maintaining a pathway for airflow. This design allows for airflow to enter an open window, pass through a classroom and subsequently pass through the open transom. Airflow then enters the hallway, passing through the opposing open classroom transom, into the opposing classroom and finally exits the building on the leeward side (opposite the windward side) (Figure 2). With all windows and transoms open, airflow can be maintained in a building regardless of the direction of the wind. This system fails if the windows or transoms are closed (Figure 3). Most of the transoms observed were inoperable and/or had hardware removed.

The cafeteria is designed to be ventilated by air handling units (AHUs). The AHUs are located in lofts flanking the stage and provide supply air through vents near the ceiling and ducted back to the AHUs via return vents on the front of the stage (Picture 10). School officials reported that only one of the AHUs routinely operates and the other one is operated as needed. The system was not operating during occupancy at the time of the assessment. MDPH staff examined the AHU in the left side loft and found the actuator bar to the fresh air intake was disconnected (Picture 11).

Ventilation for modular classrooms is provided by rooftop AHUs (Picture 12). Fresh air is distributed to classrooms via ductwork connected to ceiling-mounted air diffusers and drawn back to the units through ceiling-mounted grilles. Thermostats control each heating, ventilating and air conditioning (HVAC) system and have fan settings of “on” and “automatic”. Thermostats were set to the “automatic” setting (Picture 13) in both modular rooms surveyed during the assessment. The automatic setting on the thermostat activates the HVAC system at a preset temperature. Once the preset temperature is reached, the HVAC system is deactivated. Therefore, no mechanical ventilation is provided until the thermostat re-activates the system.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment. Please note that several components of the mechanical ventilation system cannot be balanced in their current condition.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools because a majority of occupants is young and considered a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix A.

Temperature readings ranged from 72° F to 82° F, which were above or near the upper end of the MDPH recommended comfort guidelines in a number of areas during the assessment. The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. In addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., AHUs not operating, exhaust vents obstructed/deactivated). Lack of temperature control and excessive heat complaints were expressed in several areas, including the kindergarten classroom and nurses office. The heat complaints in the kindergarten classroom reportedly stem from poor temperature control of the univent from the thermostat. The excessive heat in the nurse’s office is a result of uninsulated heating pipes in the crawlspace below this area. School officials reported that asbestos pipe insulation was removed and the pipes were not reinsulated with an alternative material.

The indoor relative humidity measurements ranged from 25 to 39 percent, which were below or near the lower end of the MDPH recommended comfort range. The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity would be expected to drop below comfort levels during the heating season. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

The building has a history of roof leaks and water damage. As discussed, a new roof was installed several months prior to the MDPH assessment. Water damaged ceiling tiles were observed in a number of areas throughout the building (Picture 14). Water-damaged ceiling tiles can provide a source of mold growth and should be replaced after a water leak is discovered and repaired. In some areas, the ceiling tile system consists of ceiling tiles adhered directly to the ceiling (Picture 15). Removal of these ceiling tiles is difficult because it necessitates the destruction of the tiles.

Around the perimeter of the building, shrubbery and other plants were observed in close proximity to univent air intakes (Picture 16), which can draw in plant debris, pollen and or mold. Several open utility holes were also observed on the exterior of the building, which can provide a means of water penetration and/or pests into the building (Picture 17). Missing/damaged gutters and downspouts were observed around the modular building

(Picture 18). Gutters and downspouts are designed to direct rainwater away from the base of the building.

Plants were noted in several classrooms. Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents to prevent the aerosolization of dirt, pollen or mold (Picture 19).

Spaces between the sink countertop and backsplash were also seen in several areas (Table 1). Improper drainage or sink overflow can lead to water penetration into countertop wood, the cabinet interior and areas behind cabinets. If these materials become wet repeatedly they can provide a medium for mold growth.

Other Concerns

Indoor air quality can be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants; however, the pollutant produced is dependent on the material combusted. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, MDPH staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient-Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from 6 criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND. Carbon monoxide levels measured in the school were also ND (Table 1).

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter (μg/m^3) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 μg/m^3 over a 24-hour average (US PEA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 52 μg/m^3. PM2.5 levels measured indoors ranged from 22 to 47 μg/m^3 (Table 1), below background as well as the NAAQS of 65 μg/m^3. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be impacted by the presence of materials containing volatile organic compounds (VOCs). VOCs are substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. Outdoor air samples were taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC measurements throughout the building were also ND (Table 1).

Please note, that the TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use of TVOC containing products. While no measurable TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several areas contain photocopiers and lamination machines. Lamination machines can produce irritating odors during use. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). A local exhaust vent is located in the ceiling of the teacher's workroom (Picture 20); however, no draw was detected from this vent to help reduce excess heat and odors.

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to prevent excessive dust build up.

In an effort to reduce noise from sliding chairs, tennis balls had been sliced open and placed on chair legs (Picture 21). Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and off-gas TVOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix B (NIOSH, 1998).

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers.
2. Operate all ventilation systems that are operable throughout the building (e.g., cafeteria, classrooms) continuously during periods of school occupancy and

independent of thermostat control. To increase airflow in classrooms, set univent controls to “high”.

3. Set the thermostat for modular classrooms to the fan “on” position to operate the ventilation system continuously during the school day.
4. Inspect exhaust motors and belts for proper function. Repair and replace as necessary.
5. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
6. Close classroom doors to facilitate air exchange via the mechanical ventilation system.
7. Consider restoring transoms to original function to provide cross-ventilation as per the original design of the building.
8. Consider having ventilation systems re-balanced every five years by an HVAC engineering firm.
9. Consider installing mechanical exhaust ventilation in the kitchen and copy room to remove excess heat and pollutants.
10. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

11. Ensure roof leaks are repaired, and replace any remaining water-stained ceiling tiles (for dropped ceilings). Examine the areas above and around these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
12. For removal of tiles directly adhered to the ceiling, such removal would be considered a renovation activity that can release particulates and spores in particular, if the material is moldy. Replacement of ceiling tiles may involve glues that contain VOCs. In order to minimize occupant exposure, repairs should be done while the building is unoccupied.
13. Reinstall missing downspouts to direct rainwater away from the building.
14. Ensure univent air intakes are clear of plant growth. Remove foliage to a minimum of five feet away from the exterior of the building.
15. Seal open utility holes in the building exterior to prevent water intrusion, drafts and/or pest entry.
16. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
17. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water damage and mold/mildew growth, repair/ replace as necessary. Disinfect areas with an appropriate antimicrobial, as needed.
18. Change filters for air-handling equipment (i.e., univents, AHUs, window mounted ACs) as per the manufacturer's instructions or more frequently if needed.

19. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

20. Consider discontinuing the use of tennis balls on walker legs to prevent latex dust generation. Alternative "glides" can commonly be purchased from office supply stores, see Picture 22 for an example.

21. Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner to allow for a timely remediation of the problem.

22. Consider adopting the US EPA (2000b) document, "Tools for Schools", to maintain a good indoor air quality environment on the building. This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

23. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/MDPH/iaq/iaqhome.htm.

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Figure 2 **Cross Ventilation in a Building Using Open Windows and Transoms**

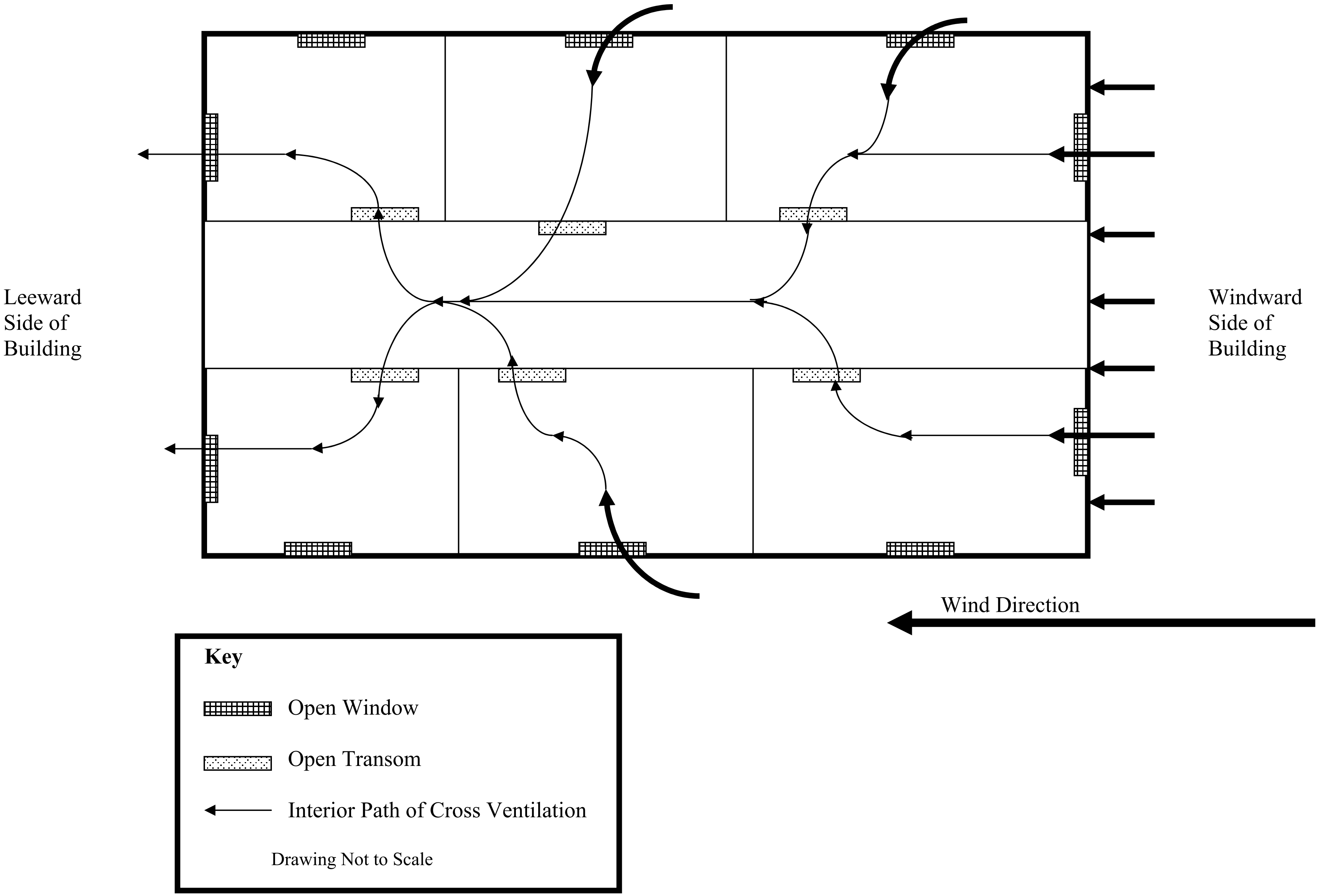
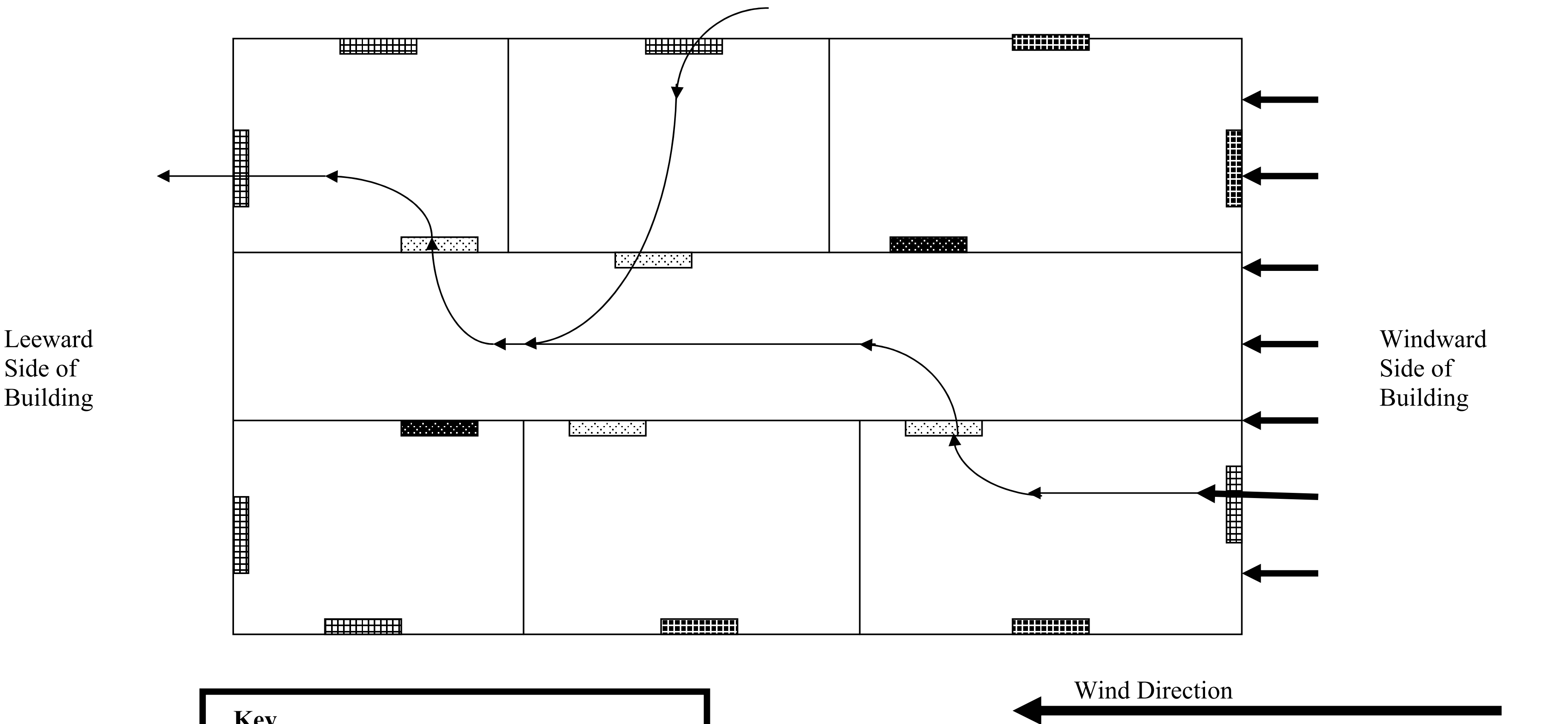
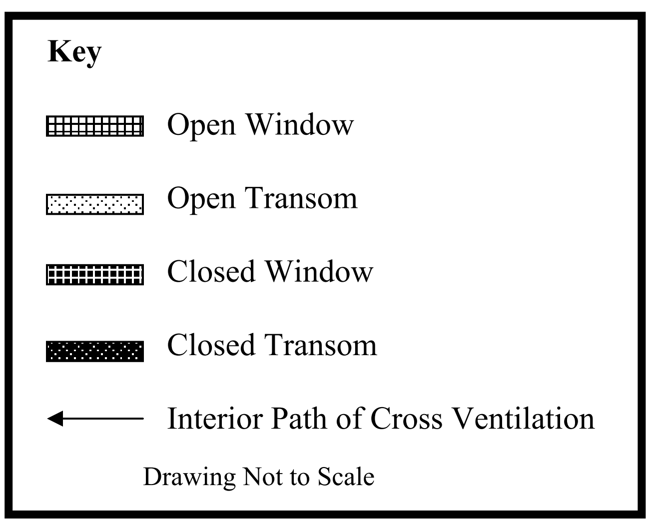


Figure 3 **Inhibition of Cross Ventilation in a Building with Several Windows and Transoms Closed**





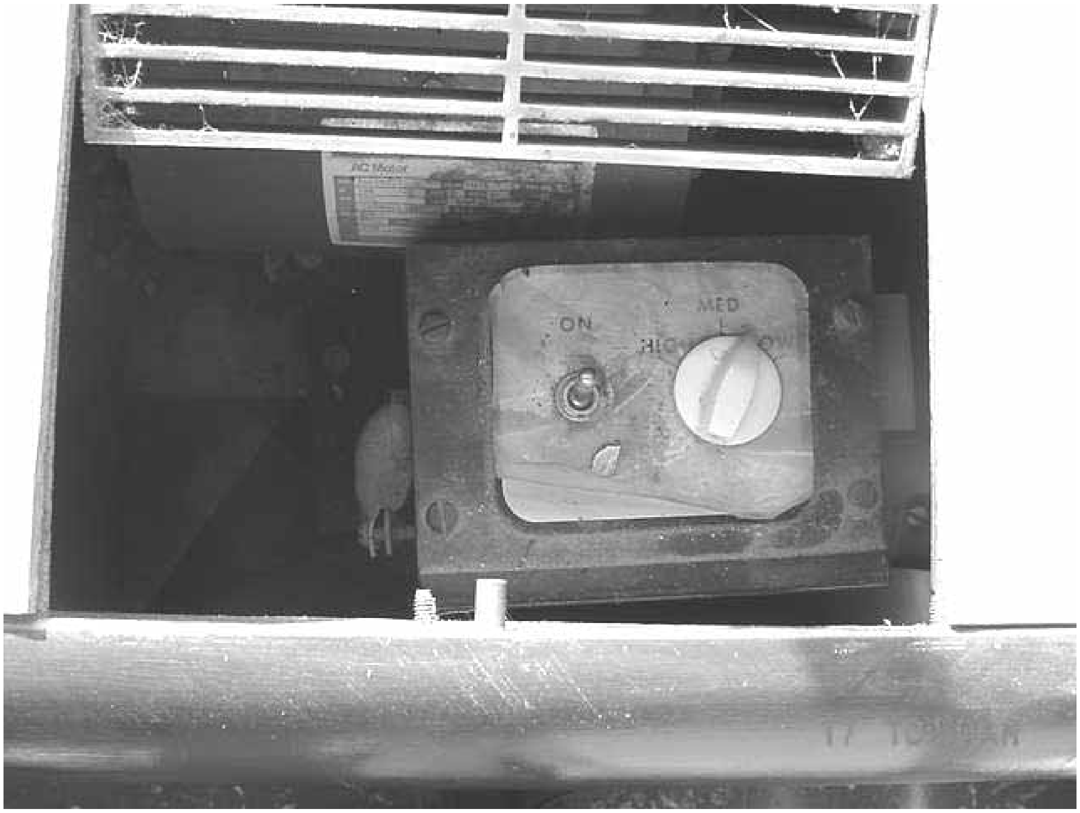
Picture 1

Classroom Univent in Original Portion of the Building (1940's Vintage)

Picture 2

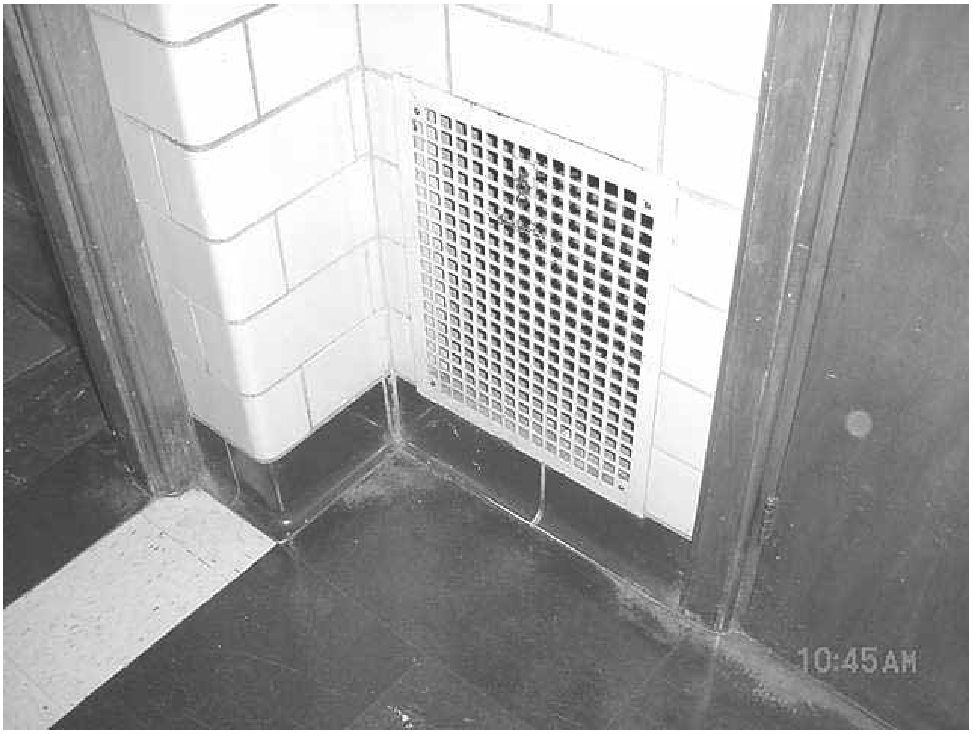
Univent Fresh Air Intake

Picture 3



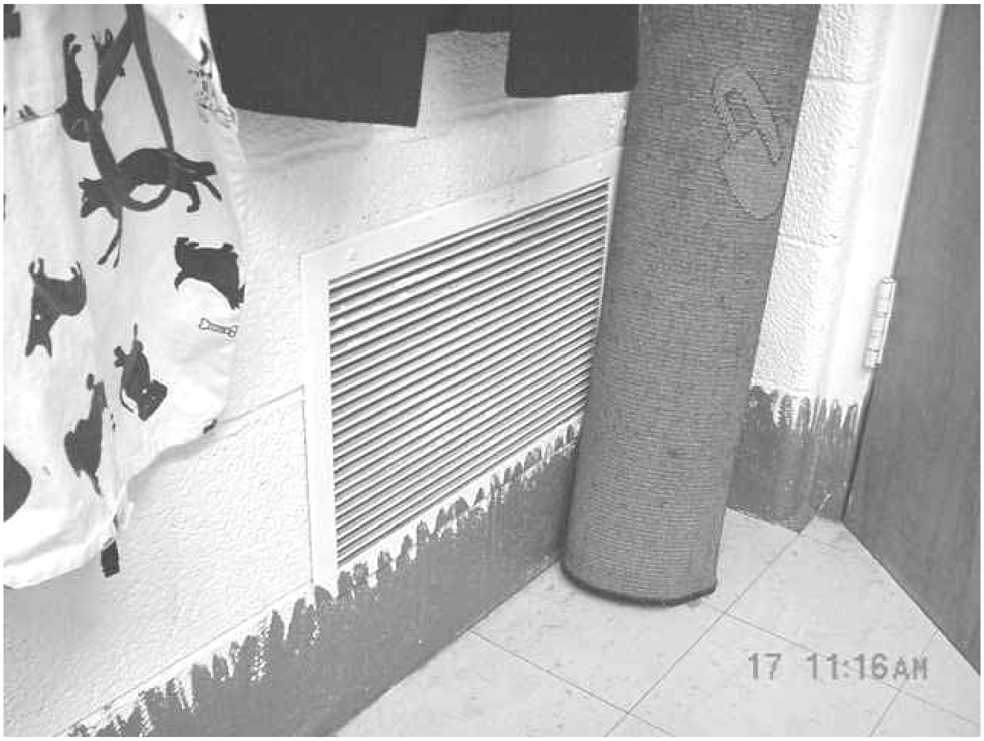
Univent Control Panel, Note Fan Speed Dial on Right

Picture 4



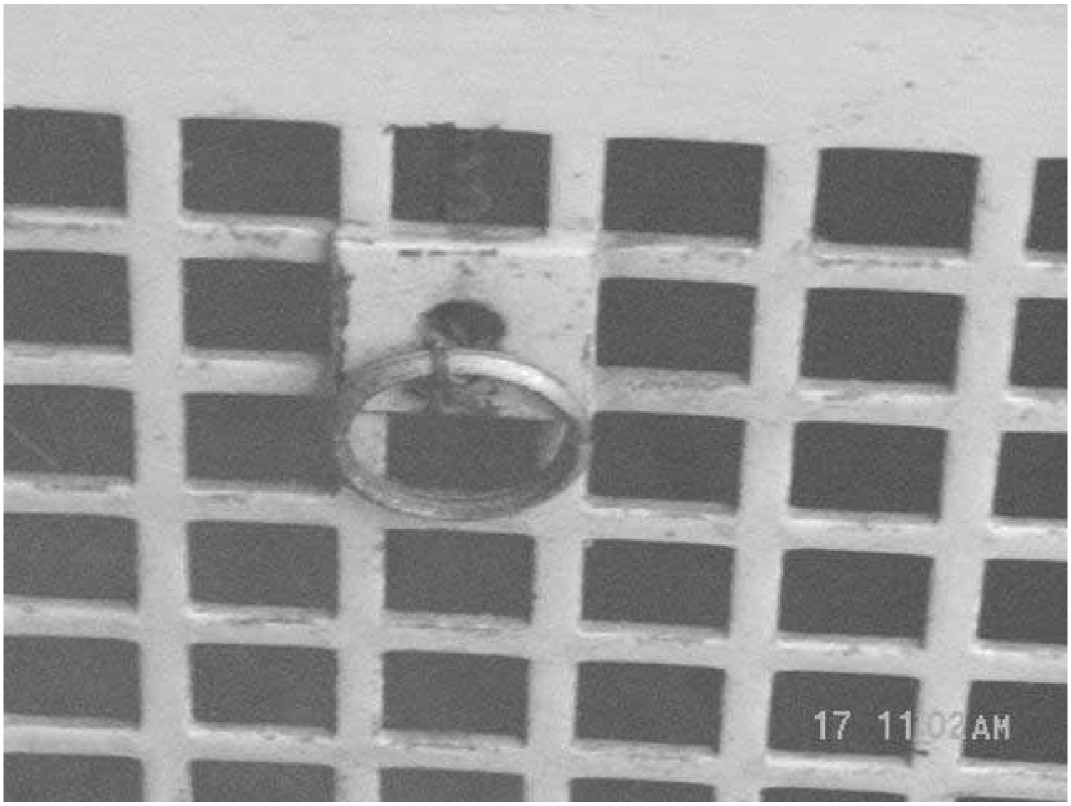
Classroom Exhaust Vent in 1949 Portion of the Building

Picture 5



Wall-Mounted Exhaust Vent in Addition Classroom

Picture 6



Close-Up of Exhaust Vent Pull Chain in 1949 Classrooms

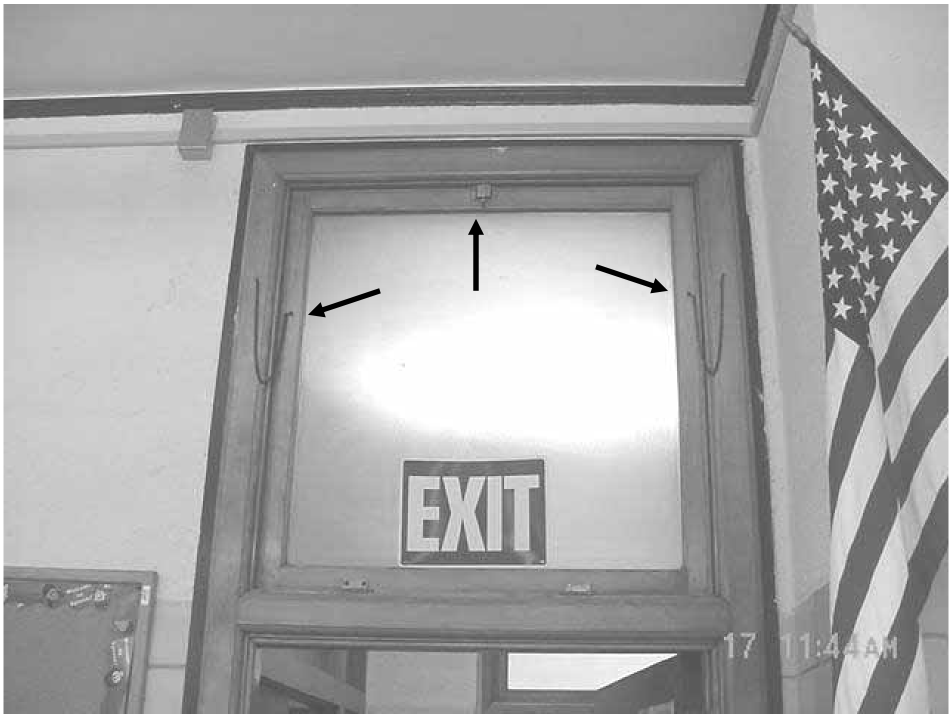
Picture 7

Obstructed Classroom Exhaust Vent

Picture 8

Classroom Exhaust Vent Obstructed by Open Hallway Door

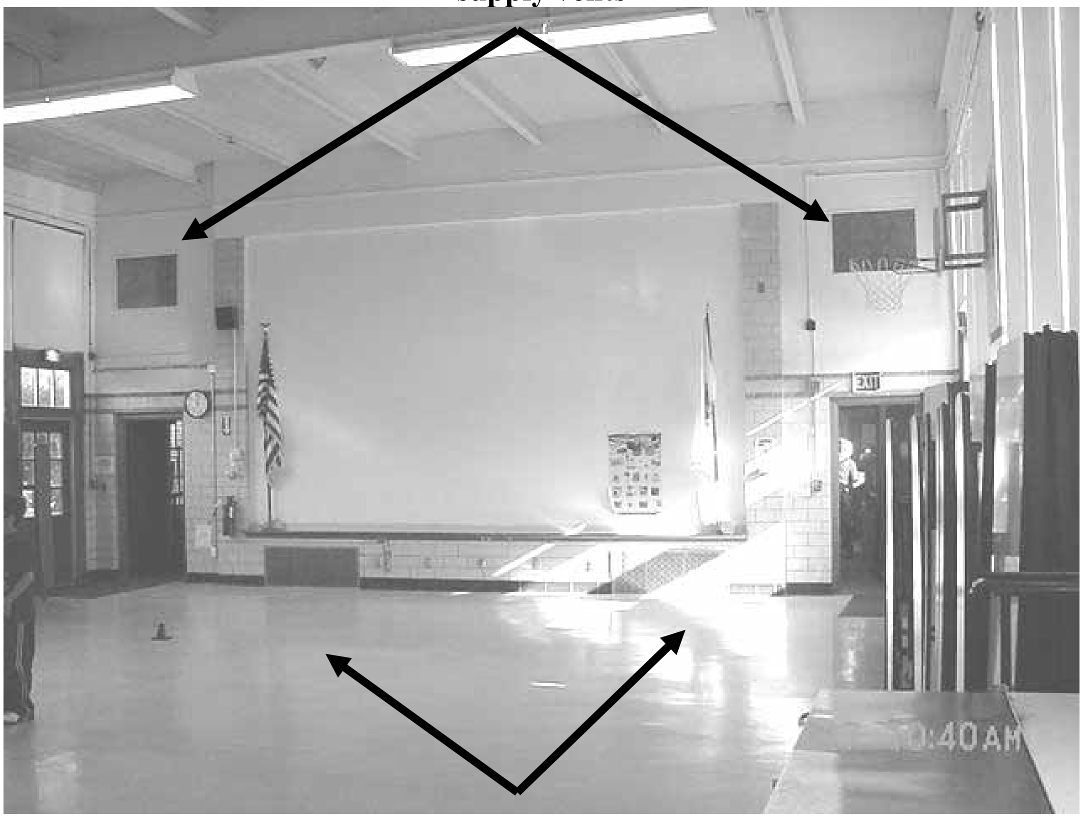
Picture 9



Transom Above Classroom Door Note Lock and Chain Mechanisms

Picture 10

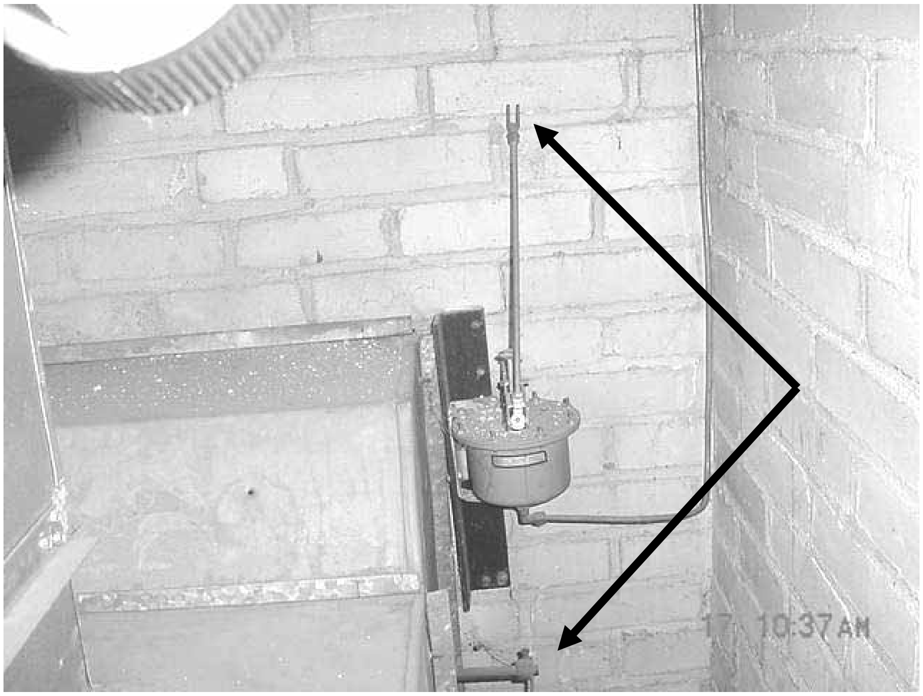
supply vents



exhaust vents

View of Stage and Ventilation Components

Picture 11



Disconnected Actuator Bar (to Left Side) Cafeteria AHU

Picture 12

Rooftop AHUs for Modular Classrooms

Picture 13

Fan Control Switch Set to the "Auto" Setting on Modular Room Thermostat

Picture 14

Water Damaged Drop Ceiling Tiles in Modular Classroom

Picture 15

Water Damaged Ceiling Tiles, Note these Tiles are Adhered Directly to the Ceiling

Picture 16

Shrubbery in Close Proximity to Univent Air Intake

Picture 17

Open Utility Hole in Exterior Wall

Picture 18

Missing Downspout and Elbow Extension

Picture 19

Plants on Top of Univent in Classroom

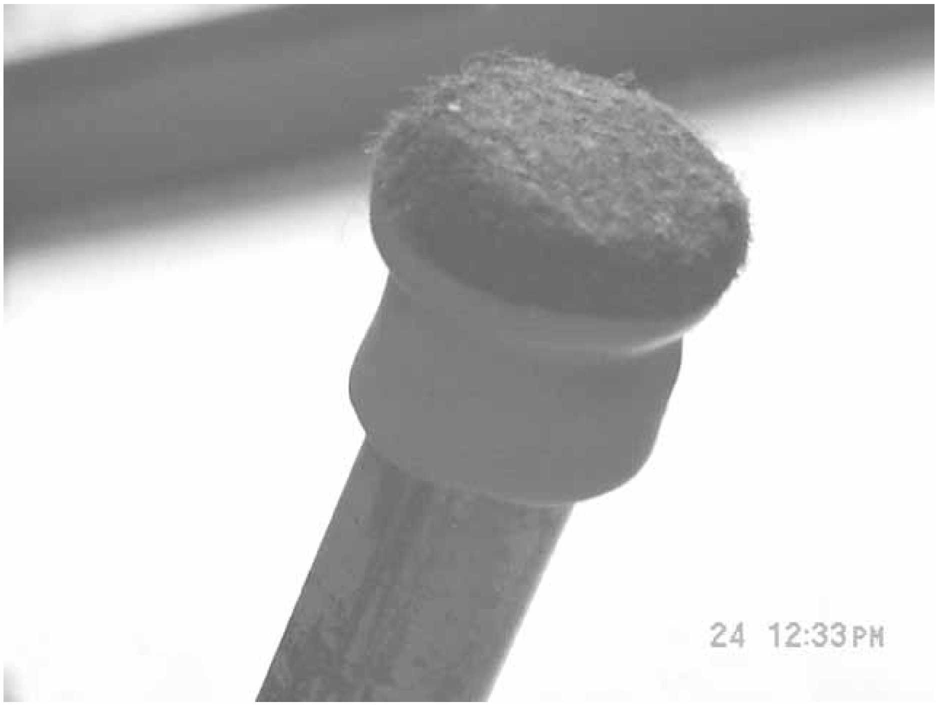
Picture 20

Lamination Machine and Ceiling Exhaust Vent in Teachers Workroom

Picture 21

Frayed Tennis Ball on Chair Leg in Classroom

Picture 22



"Glides" for Chair Legs That can be Used as an Alternative to Tennis Balls

Falls Elementary School | **Indoor Air Results**

One Jackson Street, North Attleborough, MA

Table 1

November 17, 2004

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Background (outdoors)	50	39	382	ND	ND	52		-	-	-	Atmospheric Conditions: mostly sunny, winds light and variable, moderate to heavy auto traffic, construction
Cafeteria/ Gymnasium	72	39	1000	ND	ND	47	26	Y	Y	Y	2 AHUs-one reportedly does not work, one deactivated, actuator arm disconnected from air intake louver, 3 windows open
Kitchen	74	32	709	ND	ND	39	0	N	N	Y	Slight gas odors-stove, local hood exhaust-operable, DO
Psychologist	75	31	682	ND	ND	32	0	Y	N	N	DO
Main Office	79	25	623	ND	ND	32	3	Y	Y	Y	DO, window open, exhaust off/blocked by boxes, photocopier
Room 100	76	31	1410	ND	ND	36	1	Y	Y	Y	Exhaust off, UV obstructed, 22 students gone 5 min., cleaning products/odors, DEM, PF, Breach sink/countertop, 9 CT

ppm = parts per million parts of air
CT = ceiling tile
AD = air deodorizer
AP = air purifier
CD = chalk dust

µg/m3 = microgram per cubic meter
WD = water damage
DEM = dry erase marker
DO = door open
PC = photocopier

UV = univent
CF = ceiling fan
PF = personal fan
TB = tennis balls
UF = upholstered furniture

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Table 1

Location/ Room	Tem p (°F)	Relative Humidity (%)	Carbo n Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Room 101	77	28	1471	ND	ND	35	24	Y	Y	Y	Exhaust off/blocked by furniture, UV blocked by furniture, DO, Plants, DEM
Kindergarten	81	31	733	ND	ND	34	22	Y	Y	Y	Window open, DO, exhaust blocked, cleaning products, DEM, excessive heat complaints
Nurse	82	25	974	ND	ND	36	1	N	N	Y	DO, excessive heat from crawlspace pipes
102	76	29	1069	ND	ND	36	9	Y	Y	Y	UV obstructed, plants, 13 CT, DO, DEM
103	74	27	762	ND	ND	33	22	Y	Y	Y	Exhaust – off, UV obstructed, DEM, DO
104	74	31	878	ND	ND	36	13	Y	Y	Y	Exhaust – off, UV plants, DEM, DO, window open
105	75	28	555	ND	ND	31	0	Y	Y	Y	Exhaust – off, DEM, DO, dusty, PF, window open

ppm = parts per million parts of air
CT = ceiling tile
AD = air deodorizer
AP = air purifier
CD = chalk dust

µg/m3 = microgram per cubic meter
WD = water damage
DEM = dry erase marker
DO = door open
PC = photocopier

UV = univent
CF = ceiling fan
PF = personal fan
TB = tennis balls
UF = upholstered furniture

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

Falls Elementary School **Indoor Air Results**

One Jackson Street, North Attleborough, MA **Table 1** **November 17, 2004**

Location/ Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (*ppm)	Carbon Monoxide (*ppm)	TVOCs (*ppm)	PM2.5 (µg/m3)	Occupants in Room	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Teacher's Lounge	76	30	1216	ND	ND	41	04	N	N	Y	Burnt coffee odor, DO, lamination machine
106	74	31	1400	ND	ND	36	1	Y	Y	Y	24 occupants gone 5 min, Plants, DEM, breach sink/countertop, FC, exhaust vent behind hallway door-when open
Computer Lab	76	32	1012	ND	ND	24	1	Y	Y	Y	Supply off, 25 computers, thermostat fan « auto », 11 CT
200	76	29	901	ND	ND	28	23	Y	Y	Y	Window open, exhaust-off, DO, DEM, PF, TB
201	76	30	994	ND	ND	27	25	Y	Y	Y	Exhaust-off/blocked by furniture, DO, DEM, plants, PF
202	77	27	928	ND	ND	24	25	Y	Y	Y	DEM, windows open
203	76	28	773	ND	ND	31	22	Y	Y	Y	UV-obstructed by furniture, DO, TB, cleaning products, DEM

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									Supply	Exhaust	
205	77	30	874	ND	ND	14	20	Y	Y	Y	Exhaust – off, DEM, DO, TB, windows open, breach sink/countertop
204	78	29	1037	ND	ND	24	24	Y	Y	Y	Exhaust – off/obstructed, DEM, DO, windows open, PF, breach sink/countertop
Resource/ Reading Rm	76	32	910	ND	ND	22	0	Y	Y	N	DEM, DO
Library	74	34	1703	ND	ND	43	35	Y	Y	Y	Musty odors, thermostat fan set to « Auto », 2 MT, 5 CT
2nd Floor Resource Rm	77	31	1034	ND	ND	28	3	Y	N	Y	Exhaust-off, DEM
Teachers' Rm 2nd Floor	76	29	1024	ND	ND	28	0	N	N	Y	AC

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